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ANATOMICAL AND PHYSIOLOGICAL CHARACTERISTICS OF THE KIDNEY

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Annotatsiya:

Ushbu maqolada buyraklarning anatomik tuzilishi va fiziologik faoliyati keng yoritilgan. Buyraklar organizmda modda almashinuv mahsulotlarini chiqarish, suv-tuz muvozanatini saqlash hamda ichki muhit barqarorligini ta’minlashda muhim rol o‘ynaydi. Maqolada nefronning tuzilishi, siydik hosil bo‘lish jarayoni (filtratsiya, reabsorbsiya va sekretsiya bosqichlari) hamda buyraklarning gormonal faoliyati haqida ma’lumotlar keltirilgan. Shuningdek, buyrak faoliyatining buzilishi organizmga qanday ta’sir ko‘rsatishi ham tahlil qilingan.

Kalit so‘zlar:

buyrak, nefron, filtratsiya, reabsorbsiya, sekretsiya, siydik hosil bo‘lishi, homeostaz, gormonal boshqaruv.

Аннотация:

В данной статье подробно рассматриваются анатомическое строение и физиологические функции почек. Почки играют важную роль в выведении продуктов обмена веществ, поддержании водно-солевого баланса и гомеостаза организма. В статье описывается структура нефрона, процесс образования мочи (фильтрация, реабсорбция и секреция), а также гормональная функция почек. Кроме того, анализируется влияние нарушений работы почек на организм человека.

Ключевые слова:

почка, нефрон, фильтрация, реабсорбция, секреция, образование мочи, гомеостаз, гормональная функцияфункци.

Abstract:

This article provides a detailed overview of the anatomical structure and physiological functions of the kidneys. The kidneys play a crucial role in excreting metabolic waste products, maintaining water-electrolyte balance, and ensuring homeostasis. The paper discusses the structure of the nephron, the process of urine formation (filtration, reabsorption, and secretion), as well as the endocrine functions of the kidneys. Additionally, the impact of kidney dysfunction on the human body is analyzed.

Keywords:

kidney, nephron, filtration, reabsorption, secretion, urine formation, homeostasis, endocrine function.

Introduction

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Maintaining the stability of the internal environment in the human body, that is, ensuring homeostasis, is carried out through complex physiological systems. Within these systems, the separation (excretory) system occupies a special place. The kidneys, considered the main organs of the excretory system, perform important functions such as eliminating harmful and excess products formed in the body as a result of metabolism, maintaining water and electrolyte balance, and regulating the acid-base environment. For this reason, an in-depth study of the structure and function of the kidneys is one of the important areas of medical science. The kidneys are paired members and are located on the back wall of the abdominal cavity, on the side of the spine. Each of them has a complex anatomical structure, covered on the outside by a fibrous capsule, and the inside consists of a cortex (cortical) and a medulla (medullary) layers. The main functional unit of the kidney is the nephron. Each kidney contains millions of nephrons, through which the process of urine formation is carried out. The structure and function of the nephron are of fundamental importance in understanding the overall functioning mechanism of the kidney. The process of urine formation consists of several stages, including glomerular filtration, tubular reabsorption, and secretion. Through these processes, essential substances for the body are reabsorbed, while excess and harmful substances are excreted. At the same time, the kidneys function not only as excretory organs, but also as part of the endocrine system. They produce biologically active substances such as renin and erythropoietin, which are involved in blood pressure regulation and blood formation.

Kidney diseases are currently widespread worldwide, and their early detection and prevention are one of the most pressing problems. Kidney dysfunction leads to serious changes in the body and negatively affects the functioning of the cardiovascular system, nervous system, and other organs. Therefore, studying the normal structure and functioning of the kidneys is not only of theoretical, but also of practical importance. The purpose of this article is to study in detail the anatomical structure and physiological functions of the kidneys, analyze the main stages of urine formation, and highlight the importance of kidney function for the body.

The kidney is a paired organ that secretes urine (ren, grekchanephros). It has a loveless shape, and in a large person it is 10-12 cm long, 5-6 cm wide, 4 cm thick. Weight 120 −200 g. It is dark red in color, with a smooth surface in an adult. The anterior surface of the kidney (facies anterior) is convex, the posterior surface (facies posterior) is flatter. It has an upper end (extremitas superior), a lower end (extremitas inferior), a convex lateral edge (margo lateralis), and a concave medial edge (margo medialis). In the middle of the medial edge, a depression is located, bounded by the anterior and posterior surfaces, the renal hilum (hilus renalis). From here, arteries and nerves enter the kidney, from which the urethra, vein and lymphatic vessels come out. The kidney gate goes into the renal cavity (sinus renalis), which is immersed in it. The kidney is located on the back wall of the abdomen on the two sides of the spine in the lumbar area behind the peritoneum. The upper ends of the kidneys are located close together, while the lower ends stay longer. The left kidney is higher than the right. The upper end of the left kidney is located between the eleventh thoracic vertebra, and the lower end is located in the area of the upper edge of the third lumbar vertebra. The upper end of the right kidney is located in the area of the lower edge of the eleventh thoracic vertebra, and the lower end is located in the area of the middle of the body of the third lumbar vertebra. The twelfth rib crosses the posterior surface of the left kidney at its midpoint, and the right kidney at its upper end. The posterior surface of the kidney is covered by the diaphragm, the quadratus lumborum muscle, the transverse abdominis muscle, and the psoas major muscle. The adrenal gland is located at its upper end. The anterior surface of the kidney is covered with peritoneum and touches the internal organs. The anterior surface of the right kidney is in contact with the liver in the upper

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two-thirds, and the lower one-third is in contact with the right colic flexure. Its medial edge is touched by the descending portion of the duodenum. The left kidney is touched by the anterior surface of the upper third by the gastric, the middle by the pancreas, and the lower by the hungry intestinal scales. Its lateral edge touches the spleen and the left colic flexure. When we cut a kidney (Figure 92), we see that it consists of two different substances: an outer layer 0.4-0.7 cm thick and a core substance 2-2.5 cm thick. The bark of the kidney (cortex renalis) is reddish in color. It does not form the outer layer of the kidney, but sinks between the cornea and forms the renal columns (columna renalis). The cortex of the kidney consists of alternating light and dark parts. The light part is cone-shaped and consists of the initial parts of the straight tubules and collecting tubules of the kidney, forming a radiating part (pars radiata) in the form of a beam of light passing from the core to the cortex. In the case of a dark part, the so-called Twisted part (pars convoluta), in which the renal cells and twisted tubes are located. The cornea of the kidney (medulla renalis) is one of 10-15 renal pyramids

pyramidalis) facing the medulla, forming the renal papilla (papilla renalis), facing the renal cavity. The pyramid consists of a nephron with straight tubes and collecting tubes, which are joined to form 15-20 short suction tubes (ductuli papillares) in the area of the renal sucker. They open onto the surface of the renal papillae as suction holes (foramina papillaria). Due to these pores, the renal papilla has a sieve-like appearance, called the sieve area (area cribrosa). Five that contain 2-3 renal segments, depending on the renal structure and vascular distribution: the upper segment (segmentumsuperius), the upper segment of the anterior surface (segmentum anterius superius), the lower segment of the anterior surface (segmentum anterius inferior), the lower segment (segmentum inferior), and the posterior surface segments (segmentum posterius). A renal lobe (lobus renalis) is a renal pyramid and its adjacent cortical substance, bounded by the interlobar artery and vein lying in the renal column. Each renal lobe contains about 600 cortical lobules (lobulus corticalis) in the cortex. A segment of the cortex contains one radiate and one convoluted part, which are separated by two interlobular arteries and veins.

Main part

The renal pelvis, renal calyx, and urine formation process

The most important component of the kidney is the renal calyx (Malpighian corpuscle or renal corpuscle). The renal corpuscle consists of the glomerulus (renal corpuscle) and Bowman's capsule, where the first and main stage of urine formation, filtration, occurs. Each nephron contains a single renal corpuscle, and there are millions of such corpuscles in the entire kidney.

The renal corpuscle (Glomerulus) is a bundle of small blood vessels (capillaries) in the shape of a coil that receives blood through the afferent (incoming) arteriole and releases blood through the efferent (outgoing) arteriole. The walls of the glomeruli act as a special filtration barrier. This barrier consists of three layers: the first, the capillary endothelial layer (fenestrates — with small pores), the second, the basal membrane (a dense layer made up of collagen IV, laminin and other proteins), the third, the soles of podocytes (pedicels). Podocytes are specialized epithelial cells whose limbs form filtration cracks (filtration slits) and these cracks are lined with proteins called slit diaphragms. This three-layer structure retains large molecules (proteins, blood cells), but easily passes water, ions, glucose, amino acids, urea, and other small molecules.

The Bowman's capsule surrounds the glomerulus and has a double wall. The outer (parietal) floor consists of simple flat epithelial cells, while the inner (visceral) floor consists of podocytes. The space inside the capsule collects the primary urine (ultrafiltrate) filtered from the glomerulus. The glomerulus and Bowman's capsule together form the renal corpuscle (Malpighian corpuscle).

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The first step in urine formation is glomerular filtration. Blood enters the glomerulus under high pressure. Glomerular hydrostatic pressure on filtration (about 55 mm wire. column), pressure in Bowman's capsule (15mm wire. column) and oncotic pressure of blood plasma (30 mm wire. column). The resulting net filtration pressure is about 10 mm wire. column, producing 170–180 liters of primary urine per day. This filtrate is almost identical to plasma, containing almost no proteins or cells. Glomerular filtration rate (GFR) is the main indicator for assessing kidney function.

The second stage of urine formation is reabsorption (reabsorption). Primer urine exits the Bowman's capsule and passes into the proximal tube. Here, 65–70% of the filtrate is reabsorbed: water, glucose, amino acids, sodium, chloride, bicarbonate ions, and other nutrients are returned to the blood. The proximal tubule contains squamous epithelium and a large number of mitochondria, which provide active transport. The Henle loop operates a countercurrent mechanism: water is removed in the descending limb, and ions are actively removed in the ascending limb. This creates a hyperosmotic environment in the medulla and helps concentrate the urine. Final adjustment occurs in the distal tubule and collecting ducts under the influence of aldosterone (sodium retention, potassium excretion) and antidiuretic hormone (ADH — water retention).

The third stage is secretion. In the tubes, additional substances (hydrogen ions, potassium, ammonium, some drugs and poisons) are actively released from the blood vessels into the urine. This process further enhances the kidney's ability to cleanse the blood. As a result, only 1.5–2 liters of final urine are produced from 180 liters of primary urine per day. The rest is reabsorbed into the blood. Urine formation is under the control of a complex hormonal and nervous system. The renin-angiotensin-aldosterone system regulates blood pressure, ADH regulates water balance, and natriuretic peptides regulate the excretion of excess sodium and water.

Damage to the renal bladder and renal jaw (glomerulonephritis, diabetic nephropathy, hypertonic nephroslerosis) disrupts the filtration process, leads to the transfer of protein to the urine (proteinuria), the formation of blood cells (hematuria) and kidney failure. Therefore, the healthy state of the renal pelvis and glomerulus is of crucial importance in maintaining the internal environment of the entire organism.

Each stage of these processes is accompanied by specific enzymes, transport proteins and energy expenditure. For example, in a proximal tube, a sodium-potassium pump displaces millions of ions per second per nephron. The countercurrent system in the Henle's loop is even more highly developed in animals adapted to living without water. In the human kidney, the maximum concentration of urine can reach about 1200 mOsm/kg.

Kidney hormones

The kidney is not only an excretory organ, but also an important organ with endocrine activity. It produces several important hormones and biologically active substances that control the homeostasis of the whole organism.

1. Renin

It is produced by the yukstaglomerular cells of the kidney (juxtaglomerular cells). Renin is an enzyme that converts angiotensinogen in blood plasma to angiotensin. This is the beginning of the renin-angiotensin-aldosterone system (RAAS). RAAS increases blood pressure, retains sodium and water, and constricts blood vessels. Renin secretion is increased by a decrease in blood pressure, activation of the sympathetic nervous system, or a decrease in sodium levels.

2. Erythropoietin (EPO)

It is produced by the peritubular interstitial cells of the kidney. Erythropoietin stimulates the production of erythrocytes (red blood cells) in the red bone marrow. Hypoxia (lack of oxygen) increases EPO synthesis. This hormone is one of the main causes of anemia in kidney failure. Artificial EPO drugs are used to treat anemia.

3. Calcitriol (active Vitamin D3)

It converts 25-hydroxyvitamin D to 1,25-dihydroxyvitamin D (calcitriol) in the proximal tubules of the kidney. Calcitriol increases calcium and phosphorus absorption in the intestine, regulates calcium deposition in bone tissue, and, together with parathyroid hormone, maintains calcium balance. Calcitriol deficiency in kidney failure causes osteomalacia and secondary hyperparathyroidism.

4. Other biologically active substances

Prostaglandins (PGE2, PGI2) — improve renal blood flow, dilate blood vessels, and increase natriuresis (sodium excretion).

Uromodulin (Tamm-Horsfall protein) — produced in the collecting ducts, protects against urinary tract infections and prevents crystal formation. Dopamine — locally enhances natriuresis. Kidney hormones are closely related. For example, the RAAS system controls blood pressure, EPO controls blood composition, and calcitriol controls mineral balance. In chronic kidney disease, the production of these hormones is disrupted, resulting in arterial hypertension, anemia, bone disease, and water-electrolyte imbalance.

Formation and excretion of urine in the kidney

The kidney is one of the most important excretory and homeostatic organs in the human body, and the formation of urine in it is a complex and multi-stage process. Urine formation occurs in the nephrons, and this process includes the stages of filtration, reabsorption, and secretion. Each kidney contains millions of nephrons, each of which processes hundreds of liters of blood per day. Urination helps the body eliminate waste, maintain water and electrolyte balance, regulate acid-base balance, and control blood pressure. The first and most important step in urine formation is glomerular filtration. The renal corpuscle, or Malpighian corpuscle, contains the glomerulus (renal capsule). The glomerulus receives blood through the afferent arteriole. The blood is under high hydrostatic pressure in the glomerular capillaries (about 55 mm wire. column). Under this pressure, the water, ions, glucose, amino acids, urea, uric acid, and other small molecules of the blood plasma pass into the Bowman's capsule. The filtration barrier consists of three layers: the capillary endothelium, the basement membrane, and the podocyte foot processes. Large molecules (proteins) and blood cells are not filtered. As a result, an average of 170–180 liters of primary urine (ultrafiltrate) is produced per day. Filtration rate (GFR) is the main indicator of kidney function. Primary urine leaves the Bowman's capsule and enters the proximal tubule. Here, the second stage of urine formation begins - reabsorption. The epithelial cells of the proximal tubule have a brush-like structure and contain a large number of mitochondria. 65–70 percent of the filtrate is reabsorbed here. Glucose, amino acids, vitamins, sodium, chloride, bicarbonate, and most of the water are returned to the blood by active and passive transport. The sodium-potassium pump (Na^+/K^+-ATPase) plays a key role in this process. Some toxic substances and drugs are also secreted in the proximal tubule. The next stage occurs in the Henle loop. The Henle hook consists of descending and ascending legs. The descending leg is highly permeable to water, and due to the hyperosmotic environment of the medulla, water exits through the osmosis and urine is concentrated. The ascending limb does not transport water, but actively secretes sodium, potassium, and chloride ions into the blood. This is called the countercurrent multiplier system and allows the osmolality within the medulla to reach

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1200–1400 mOsm/kg. As a result, the urine becomes more concentrated. The distal tubule and collecting ducts are where the final adjustment of urine occurs. In the distal tubule, sodium is reabsorbed under the influence of the hormone aldosterone, while potassium and hydrogen ions are secreted. Calcium and phosphorus are also regulated here. In the collecting ducts, aquaporin-2 channels are activated by antidiuretic hormone (ADH or vasopressin), allowing a large amount of water to be reabsorbed into the blood. If the body has too much water, ADH decreases and urine becomes dilute (diuresis increases). Conversely, if there is too little water, ADH increases and concentrated urine is produced. Several assembly tubes merge and open into the renal papillae, and urine falls into the renal pelvis (pelvis).

The resulting urine passes from the kidney through the ureters (ureters) to the bladder. The urinary tract pushes urine down through peristaltic movements. Urine collects in the bladder and is stored there by special sphincters. When the bladder is full, the process of urination (micturition) begins under the control of the brain and spinal cord. Urine is expelled from the bladder through the urethra (urinary tract). An average adult produces 1.5–2 liters of urine per day, but this amount depends on the amount of water consumed, diet, temperature, and other factors.

The formation and excretion of urine is carried out under complex nervous and hormonal control. While the sympathetic nervous system reduces renal blood flow, the parasympathetic system stimulates urination. Among the hormones, the renin-angiotensin-aldosterone system, ADH, atrial natriuretic peptide (ANP), etc. play a major role. Disruption of these processes leads to acute or chronic renal failure, urinary tract infections, kidney stones, and other problems. In general, the formation and excretion of urine in the kidneys is a perfect mechanism for maintaining the internal environment of the body. Thanks to the coordinated work of millions of nephrons, complex transport systems, and hormonal regulation, the human body is cleansed of waste and vital substances are retained. Each stage of these processes has its own biochemical and physiological characteristics, which are of great importance in medicine for the diagnosis and treatment of kidney diseases.

Conclusion

The kidney is a central member in the maintenance of homeostasis in the human body. Its main functional unit is the nephron, with millions of nephrons per kidney. The renal corpuscle (Malpighian corpuscle) is the beginning of the nephron and is composed of the glomerulus (renal corpuscle) and Bowman's capsule. Glomerular filtration under high pressure produces 170–180 liters of primary urine per day. Subsequent processes of reabsorption, secretion and concentration occur in the proximal tube, Henle hook, distal tube, and assembly tubes, resulting in the return of water, electrolytes, and nutrients needed by the body to the blood, while waste is excreted in the urine. The countercurrent mechanism, hormonal control (ADH, aldosterone, renin-angiotensin system), and complex transport systems ensure the high efficiency of the kidney. Any damage to the renal pelvis and calyx disrupts the filtration process, leading to chronic kidney failure, hypertension, anemia, and other serious complications. Therefore, it is important for everyone to maintain kidney health, treat diabetes and arterial hypertension in a timely manner, drink enough water, and avoid harmful habits. Due to the limited regenerative capacity of nephrons, their preservation requires the constant implementation of preventive measures.

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